Understanding the Diverse Particle Environment at the Lunar South Pole Through Simple Sample Collection

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NASA's Artemis Program encompasses sustained human and robotic activity near the lunar South Pole, with support from orbital assets and a regular cadence of landings and launches. This architecture presents a unique set of opportunities and challenges for lunar and planetary science. **A key consideration with implications for both science and exploration safety is the flux of impactors impinging mission hardware and personnel.** The Artemis site (and perhaps orbital assets) will be subject to at least three sources of impactors: (1) micrometeorites, (2) secondary impactors, (3) regolith particles accelerated by rocket exhaust during spacecraft landing and takeoff. The basic principles of these processes are understood to some degree through numerical models and laboratory experiments based on analyses of limited previous lunar mission data. However, these models are poorly constrained by lunar surface observations, pinned primarily to limited data associated with the Apollo program. *Furthermore, the Artemis architecture is unprecedented in terms of its duration and complexity, and the actual particle environment may differ significantly from predictions.* Artemis presents a critical opportunity to constrain the flux, energies, composition, and other properties of these impactors. Specifically, targeted observations and experiments deployed through Artemis (or precursor missions) could address the following:

1. **Assess the flux and composition of micrometeorites impacting the lunar surface to better understand the reservoir of these impactors (constraining models of NEO origin and depletion) and how the source (cometary vs. meteoric) of these impactors changes over time or during meteor streams.**
2. **Determine the energies and trajectories of micrometeorites to better understand their role in space weathering and the hazards posed to human and robotic lunar surface operations.**
3. **Determine the flux, energies, and trajectories of secondary impactors to better understand their role in space weathering and the hazards posed to human and robotic lunar surface operations. These observations also have implications for understanding the global impactor flux.**
4. **Determine the flux, trajectories, energies, compositions, and other physical properties of blast zone particles to better understand blast zone processes (i.e., the energy coupling between lander exhaust and the lunar surface) and the hazards posed to surface activity.**
5. **Understand the evolution of the blast zone particle load through repeated landings of variable spacecraft sizes, engine configurations, and locations.**

This diverse particle flux can be constrained through several observations and experiments, including laser detection with an active system and/or passive witness plates. However, science return would be maximized by particle capture and return to Earth for analysis in terrestrial laboratories, possibly through Aerogel-based particle collectors (Moriarty et al., 2020) which preserve particles and their trajectories.

References: Moriarty, D. P., Petro, N. E., Cohen, B. A., Metzger, P., Zolensky, M. E., Watkins, R. N., ... & Stubbs, T. J. (2020). AEGIS: Aerogel Experiment Gathering Impactor Samples. *LPI Co*, *2241*, 5141.